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Guidelines for Preparing Emergency Procedures for Nuclear Power Plants

Prepared by M. H. Morgenstern, M. J. Clausen, L. O. Foley, G. W. Levy, L. B. Myers, W. L. Rankin, R. Shikiar

Pacific Northwest Laboratory
Operated by
Battelle Memorial Institute

Prepared for
U.S. Nuclear Regulatory Commission

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Guidelines for Preparing Emergency Procedures for Nuclear Power Plants

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Prepared for
Division of Human Factors Safety
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555
NRC FIN B2337

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ABSTRACT

In response to the Three Mile Island (TMI) accident and the subsequent evaluation, the U.S. Nuclear Regulatory Commission (NRC) has published the TMI Action Plan. This Action Plan identifies the need to provide Emergency Operating Procedures that treat the lower consequence/higher probability emergencies which had not been addressed in the past, and the need to incorporate good human factors practices in these procedures. The purpose of this document is to provide input to the NRC for use in developing guidelines for writing Emergency Operating Procedures for nuclear power plants.

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GUIDELINES FOR PREPARING EMERGENCY PROCEDURES FOR NUCLEAR POWER PLANTS

1.0 INTRODUCTION

In response to the Three Mile Island (TMI) accident and its subsequent evaluations, the USNRC has published the TMI Action Plan. This plan identifies the need to provide emergency procedures that treat the lower consequence/higher probability emergencies, which had not been addressed in the past, and the need to incorporate good human factors practices in these procedures.

The purpose of this document is to provide applicants/licensees with guidance for the preparation of emergency procedures in response to the TMI Action Plan. These Guidelines will also be used by the USNRC as a standard for evaluating the adequacy of the emergency procedures.

1.1 Need for Emergency Procedures

The need for emergency procedures is stated in NUREG/CR-1278. In summary, some emergency operations contain a large number of operator actions, some of which are arbitrary in sequence and some of which require extensive decision-making on the part of the operator without proper guidance to support decision-making. The proper execution of the tasks is not always self-evident. Emergency operations may be performed under high levels of stress, which can lead to a decrease in operator performance. Finally, operator skills related to emergency operations often decline during the time period between training and use. Good emergency procedures reduce the probability of errors, because the procedure presents the information needed to operate the plant during the emergency.

1.2 Anticipated Mode of Use of Emergency Procedures

The procedure is to be used during operator training but should not include information for training purposes only. It is anticipated that once an emergency event occurs, the emergency procedure prepared under these Guidelines shall be used in the following manner:

Reactor operators will perform the Immediate Operator Actions from memory.

The licensed operator in charge of the control room will go to the Emergency Procedure and read aloud the action steps which make up the Subsequent Actions. The first series of steps in the Subsequent Actions will be the verification of the Immediate Operator Actions. Some means, such as tabs, shall be provided to help locate the Subsequent Actions.

1.3 Scope

The guidelines provided in this document can serve as the basis for the preparation and control of the emergency procedure. The engineering data required to prepare the procedure are provided in the NSSS vendor guidelines. These Guidelines shall not conflict with USNRC requirements, regulations, technical specifications, etc. The emergency procedure shall be prepared in accordance with NRC-approved vendor guidelines and with this document. In case of conflict, the regulatory documents shall prevail.

1.4 Approach and Assumptions of Guidelines

The approach used in generating these Guidelines was based on one fundamental assumption: each plant will have a single, symptom-based emergency procedure which will be used by the operator to bring the plant under control after an emergency. A diagnostics section is fundamental to this assumption. The diagnostics guides the operator to the appropriate subprocedure(s) based on assessment and verification of symptoms and plant status (see Section 4.4). The Guidelines also assume that the power plant is operated by skilled, trained operators.

1.4.1 Hierarchy of Operator Actions

These Guidelines assume a specific hierarchy of operator actions. The most basic operator action is represented in the procedures by an "action

step" (e.g., Shut valve INS-20A). Several action steps are required to successfully complete a task (e.g., Isolate the BIT). Finally, one or more tasks comprise a subprocedure (e.g., Recovery from loss of offsite power during cold leg recirculation).

1.4.2 Layout of Procedure

A two-column format presents procedural information most effectively, and the specific requirements of these Guidelines are based on that format. In this layout, operator actions are placed in the left column; notes and other supporting information are placed in the right column.

1.4.3 Mandatory and Recommended Practices

The words "shall" and "should" are used consistently in the Guidelines with the following meanings:

- shall refers to a mandatory practice
- should refers to a recommended method.

2.0 GENERAL REQUIREMENTS

2.1 Document Control Procedure

The licensee/applicant's emergency procedure shall be under the control of the licensee/applicant's document control procedure described in the SAR. The emergency procedure will be acceptable when it has been reviewed and found to be adequate by the USNRC in accord with these Guidelines and in accord with other applicable USNRC requirements.

2.2 Symptom Orientation

The emergency procedure written in accord with the Guidelines shall be symptom-oriented. The procedure used by the operators must deal with the combinations of symptoms that may trigger entry into the procedure. The procedure provides the direction to continuously evaluate and treat the current set of symptoms. The procedure must reflect the fact that the symptoms may be transient in value as plant conditions change as a result of the operator's response to the emergency. The objective of the procedure is to not only diagnose the event but also bring the plant to a safe condition.

2.3 Usability

The most fundamental requirement of an emergency procedure is that it be usable. This means that the technical information is complete and accurate and that the information is presented in such a way that the operator can find it quickly and comprehend it quickly.

Immediate Actions and Subsequent Operator Actions through the diagnostic section shall be complete. When the symptoms being treated are responding at a slow enough rate to allow the operator time to use references without interfering with his need to treat symptoms, then references may be used.

2.3.1 Completeness and Accuracy

The emergency procedure shall be complete and accurate, that is, internally consistent, technically correct, and accurate in its nomenclature. This means that it can be used to bring the plant under control without the use of other documents. Any deviation from approved vendor technical guidance shall be justified and approved in accord with applicable regulations and license requirements.

2.3.2 Accessibility

Up-to-date copies of the procedure shall be readily available in the control room. The emergency procedure shall be packaged in such a way that it can be readily located and used by the Licensed Control Room Operator in charge. Some distinct means shall be provided for identifying the emergency procedure to facilitate its location. For example, the procedures may use color-coded binders.

The emergency procedure shall be tabbed or shall have other means to facilitate quick access to relevant sections. If a large hardbound document is to be used, some means should be available to help the operator maintain his place in the document (e.g., elastic book marks).

2.3.3. Legibility

Procedures shall be typed using a minimum of 10-point type, with space and one-half or double spacing between lines. Sans serif typeface is recommended. Black print on matte-finish white paper is recommended. Any tables or figures that are reduced in size shall maintain characters that are not less than 10-point size. Foldouts are acceptable but not recommended. Attention shall be given to reproduction quality so as not to significantly degrade the legibility of the material even under reduced illumination.

2.3.4 Comprehensibility

Comprehensibility refers to the ability to use information and follow directions presented in the procedure. Comprehensibility is enhanced by the use of:

- simple and familiar language
- uniform vocabulary
- short sentences
- short paragraphs
- simple illustrations
- concrete and specific words
- simple, active, affirmative, declarative sentence structure.

The emergency procedure shall be written to be unambiguous and to require a minimum of searching, reading, studying, and conceptualizing on the part of the operator.

2.4 Organization and Content of Action Steps

The emergency procedure shall use the simplest sequence of actions necessary to deal with the emergency. All action steps related to a particular task shall be grouped together and presented in the order in which they are to be performed. Each action step shall be limited to a single operation (e.g., Stop Pump A), and shall be written in 30 words or less.

Only information necessary for the correct performance of the action step, or directly helpful in preventing errors, shall be presented in the action step. Information related to the action step but not necessary for step performance may be placed in notes adjacent to the action step (see Sections 4.5, 6.3, and 6.4).

3.0 ORGANIZATION OF PROCEDURES

The emergency procedure shall be organized in accordance with Exhibit 1.

Exhibit 1. Organization of Emergency Procedures

Cover Page

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3.1 Cover Page

The cover page shall indicate the title and number of the procedure to ensure that it is the most current revision. It shall show the required reviews and approval signatures. The cover page shall contain:

- Title and procedure number
- Date of original procedure
- Current revision number and date
- Number of pages
- Review and approvals

3.2 Table of Contents

The emergency procedure shall include a Table of Contents that lists the title and page number of the first and second level headings listed in Exhibit 1 (e.g., 6.0, 6.1, 6.2).

3.3 Scope

The emergency procedure shall have a statement of scope, which shall describe the entry conditions that would require the use of the emergency procedure.

3.4 Initiating Symptoms

This section shall consist of a list of possible initiating symptoms.

3.5 Automatic System Actions

This section shall list and describe the automatic system actions that should have occurred as a function of the engineered safety features (e.g., control rods automatically inserted).

3.6 Immediate Operator Actions

This section shall list the operator actions that are to be performed from memory immediately following the initiating symptom. The number of actions included in this section should be minimized.

3.7 Subsequent Operator Actions

This section shall provide the operator with all the action steps needed to facilitate the diagnostic effort and mitigate the situation.

3.7.1 Verify Immediate Operator Actions

The first action in Subsequent Operator Actions will always be verification of Immediate Operator Actions. This section shall describe the steps necessary to verify the Immediate Operator Actions.

3.7.2 Diagnostic Steps

This section shall present the diagnostic steps necessary to lead operators to the correct subprocedures.

3.7.3 Subprocedures

Each subprocedure is a collection of tasks envisioned as treating a specific collection of symptoms. The title of the subprocedure shall describe the objective of the tasks (e.g., Restore Feedwater Flow).

3.7.3.1 First task. Each task consists of action step(s). The title of the task shall describe its objective (e.g., Start auxiliary feedwater pump and align flow to steam generators).

3.7.3.2 Second task. (e.g., Verify steam generator level increasing.)

3.7.4 Final Conditions

This section describes the final plant conditions which should be established at the end of the subprocedure.

3.8 Appended Material

This section shall contain all required documents such as selected attachments, appendices, references, lists of abbreviations, and definitions of terms.

4.0 CONTENT OF PROCEDURES

This section of the Guidelines presents the mandatory and recommended approaches to preparing the content of emergency procedures. The section addresses the following:

- the content of action steps
- how to sequence action and diagnostic steps
- how to treat nonsequential steps
- how to prepare and use diagnostic decision aids
- how to use warning, caution, and note statements
- how to cross-reference procedures

4.1 Action Steps

The objectives of a sequence of actions should be conveyed to the operator through descriptively written task titles. Where appropriate, the conditions under which the action step is or is not performed shall be included in the step (e.g., IF pressurizer pressure is increasing, THEN...; when pressurizer pressure reaches 500 psig, stop the Reciprocal Charging Pump).

4.1.1 Immediate Operator Actions

Immediate Operator Actions shall be brief and shall include only the action step, and not their verifications. Only those actions necessary to begin to control the emergency in the first few moments shall be included as Immediate Operator Actions. Since the Immediate Operator Actions are to be performed from memory, they shall not be verified until the first task under Subsequent Operator Actions. It is imperative that Immediate Operator Actions be as brief as possible to minimize the amount of information the operator must memorize. This section shall be limited to steps that cannot be delayed and included in Subsequent Operator Actions.

4.1.2 Verification

It is important to verify that the objective of a task or a sequence of action steps has been achieved. Two types of verification are possible. The first type only indicates that an action has resulted in a command signal to some piece of equipment. The operator should not rely only on such verification where other, more positive, indications are available. The second type

of verification is a positive indication to the operator that the equipment has responded to the command. This second type of verification is preferred, and, when available, shall be included as an action step at the end of a task (e.g., Verify auxiliary feedwater flow on feedwater flow indicator FI-8). The use of multiple indications may be provided.

4.2 Sequence of Action Steps

Tasks and action steps shall be sequenced according to technical necessity, i.e., to achieve the desired objectives. The physical layout and organization of the control room is an important consideration in the preparation of emergency procedures. The procedure shall consider panel layout and workflow to enhance operator effectiveness and efficiency. Whenever possible, the following guidelines should be considered:

4.2.1 One Control Board Location

Actions shall be completed at one control board location before the procedure requires the operator to change locations. While at that one location, the operator's actions should flow from left to right and from top to bottom on the control board in a logical fashion.

4.2.2 More Than One Control Board Location

Actions that require the operator to move from one control board location to another should be sequenced so that the operator moves from left to right along the control boards.

4.2.3 More Than One Operator

When more than one operator is being assigned action steps, steps shall be sequenced in such a way that the operators will not interfere with one another.

4.3 Nonsequential Steps

Nonsequential steps are steps that appear in the procedure where they may first be required. Plant conditions, however, can dictate that steps be performed later in the sequence of actions. Any nonsequential step(s) shall be identified in some manner that facilitates the operator finding it. This requirement can be satisfied by a unique symbol such as a triangle in the margin.

4.3.1 Alternative/Optional Steps

The emergency procedure shall contain no steps that force the operator to decide which step to take without indicating the conditions under which the step should be taken. In every case, a step or sequence of steps shall be stated. Alternative steps are usually written for two general situations, described below.

4.3.1.1 Equally preferable steps. In some cases, any one of several alternative steps or sequence of steps is equally correct. In such a case, only one of these steps or sequences of steps should be stated. For example, "Open one 75-gpm letdown orifice valve" does not specify any particular valve, and thereby can lead to error. The instruction as stated may result in two operators each opening a different 75-gpm letdown valve. "Open letdown orifice valve LOV 12" is preferable.

4.3.1.2 Conditional steps. Equally preferable steps often have an implicit contingency so that Step A is preferred if one condition holds and Step B is preferred if another condition holds. In these cases, the implicit condition shall be made explicit.

Example:

6.3.3	Check LTDN STOR TK LVL.	Letdown storage tank level indicator LI-31 VB-6.
6.3.4	IF level is greater than 50 inches, THEN open LTDN ORFC VLV 12.	Letdown orifice valve 12 VB-6.
	IF NOT, open LTDN ORFC VLV 13.	Letdown orifice valve 13 VB-6.

4.3.2 Steps Requiring Recurrent Operator Attention

Procedures often include steps that require the operator to repeatedly perform a given action. These steps usually require the operator to monitor or control some plant parameter (e.g., "Monitor the RWST level throughout this procedure," or "Periodically check the auxiliary building radiation monitors for indication of ECCS leakage." These are examples of bad practice.). When feasible, these steps should be written according to the following requirements. When this step does not constrain going on to the next step, the step shall so state.

4.3.2.1 State frequency. State the frequency with which the step should be repeated (e.g., "Check the auxiliary building radiation monitors at least every 30 minutes for indication of ECCS leakage").

4.3.2.2 Mechanism for assuring operator performance. A mechanism for assuring that the operator performs the required monitoring or controlling action shall be provided. For plants in which an on-line real-time readout is available, it may be used. Where such a system does not exist, alternative systems, such as a centrally located reminder board, may be used.

4.3.2.3 State consequential action. Recurrent actions shall state the actions the operator shall take once the plant parameter reaches a given condition (e.g., Monitor the RWST level (LI-431) at least every 5 minutes. At low level alarm (15 inches), shift charging pump suction to LWST according to the following steps...).

4.3.2.4 Time-Dependent Steps

When steps are time dependent (e.g., Terminate RCS charging no sooner than 1.5 hours after...), some means such as an event clock(s) shall be provided to aid the operator in performing the step within the required time frame. Forward referencing should be provided from the step that "starts the clock" to those steps that are based on elapsed time. The forward referencing may be in the form of a listing of the time-dependent steps in the note associated with the initiating step.

4.3.3 Concurrent Tasks

Procedures often include tasks that have to be undertaken at the same time. Concurrent tasks should be written to observe the following guidelines:

- The performance of concurrent tasks shall be consistent with the number of operators available considering normal control room staffing and their availability to perform the assigned tasks.
- Whenever possible, the procedure shall explicitly state which tasks are to be performed concurrently.
- Where feasible, all tasks to be performed concurrently shall be located contiguously in the same subprocedure; this minimizes the need for the operator to flip back and forth in the procedure. A task made up of few steps shall be incorporated directly into the subprocedure. A task made up of many steps may require cross-referencing.
- When completion of a step is not a prerequisite to proceeding to the next action, it shall be so stated in the procedure.

Example:

6.8.3	Obtain primary coolant chemistry. Go to next step.	Direct chem. tech. to obtain and report primary coolant sample.

4.4 Operator Aids

Diagnostic decision aids should be used to the maximum extent possible. A decision aid is a flow chart (Exhibit 2) decision table (Exhibit 3) or other device which can be used to decide which step to take next. The outcome of a decision aid shall list the next step to be taken. How the decision aid is to be used shall be apparent to the operator by the design of the aid.

Exhibit 2. Example Diagnostic Flowchart

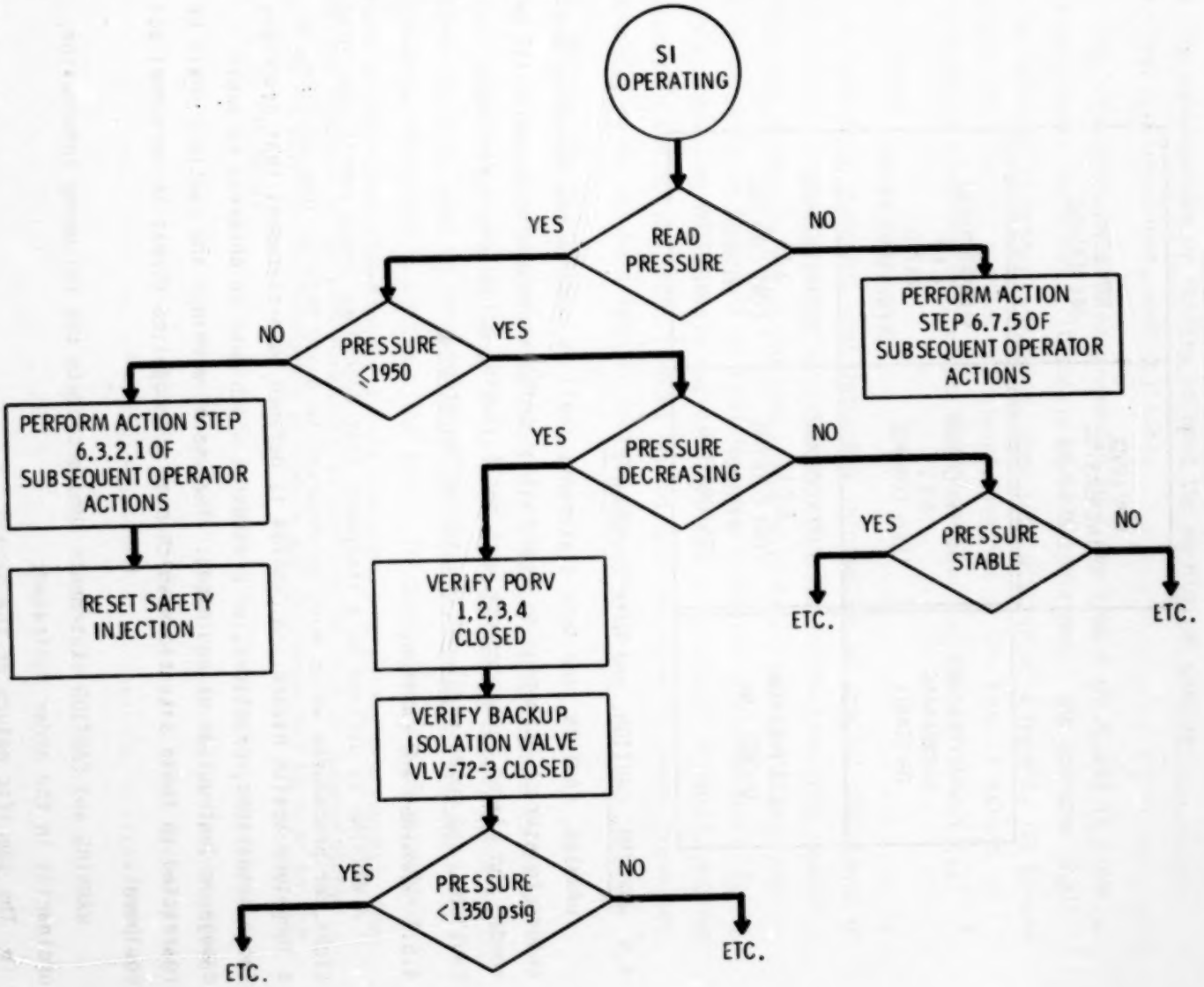

Exhibit 3. Decision Table Example

	RPV LEVEL INCREASING OR STABLE	RPV LEVEL DECREASING
RCS PRESSURE INCREASING OR STABLE	SUBPROCEDURE 6.3.1 LEVEL CONTROL	SUBPROCEDURE 6.3.2 RAPID DEPRESSURIZATION
RCS PRESSURE DECREASING	SUBPROCEDURE 6.2.1 CORE COOLING WITHOUT RESTORATION	SUBPROCEDURE 6.4.3 CORE COOLING WITHOUT INJECTION

4.5 WARNING, CAUTION, and Note Statements

WARNING, CAUTION, and Note statements shall be used in the emergency procedure to attract attention to essential or critical information, and shall be worded and placed in accordance with the following guidelines. Warnings, cautions, and notes shall not contain action steps.

4.5.1 WARNINGs and CAUTIONs

A WARNING is defined as a statement that describes those conditions, practices, or procedures which must be observed to avoid injury, loss of life, or a long-term health hazard. A CAUTION is defined as a statement that describes those conditions, practices, or procedures which must be observed to avoid damage or destruction of equipment. The use of warnings and cautions shall be restricted to those situations which pose a recognized threat to personnel and equipment.

WARNING and CAUTION statements should contain the following information, ordinarily in the order indicated:

- The specific nature of the hazard
- The precautions necessary to avoid or minimize the hazard

- The location or source of the hazard
- The consequences of failing to heed the warning or caution
- Time considerations, when critical.

The information should be presented in a few simple words and in clear, straightforward sentences. It should be self-contained: the operator shall not be referred elsewhere. However, when the location of a hazard, its consequences, and remedial actions are clearly implied by the type of hazard, or have appeared elsewhere on the same page, such information may be omitted.

4.5.2 Notes

A Note is a statement that describes information of special importance or interest, or that aids in job performance. This is information that should enhance the understanding of the procedure, will facilitate decisions, and would otherwise be difficult to find and incorporate in the procedure. For example, locations of controls and displays should be placed in Notes, and not included in the action steps. Notes depend upon the material being presented and therefore do not have special content requirements.

4.6 Referencing Procedures

All information necessary to carry out a task or subprocedure shall be consolidated in one place. Once the sequence of actions is begun, there shall ordinarily be no need to refer to other parts of the emergency procedure for information necessary to continue the task. In cases where a task or subprocedure is described elsewhere (e.g., in the normal operating procedures), the detailed sequence of actions necessary to perform the task or subprocedure shall be included in the emergency procedure and reference may be made to the source in the Notes.

5.0 WRITING STYLE

Emergency procedures shall be written to be simple, specific, and unambiguous.

5.1 Readability Measures

Readability is determined by word length and sentence length. The readability of the emergency procedure shall be determined through a sampling procedure. Take three samples of approximately 100 words from random locations in the procedure. Stop at the sentence that has closest to 100 words. Numbers and abbreviations are counted as words (as they are pronounced). The average number of syllables per word, calculated over the three samples, should not exceed 1.6 syllables per word. The average number of words per sentence, calculated over the three samples, should not exceed 15 words per sentence.

5.2 Sentence Structure

Sentences and clauses shall be written using simple word order (i.e., subject, verb, object) to the maximum extent possible. An exception is action steps. Sentences directing the actions of the operator shall be in the active voice and imperative mode; that is, they usually begin with an action verb and the subject is understood (e.g., Shut Valve V21B). All steps shall be in positive form ("Shut the container") rather than negataive form ("Do not leave the container open") unless the meaning demands the negative form. Modifiers, including prepositional phrases, shall be as close as possible to the word modified. These word order requirements shall be relaxed only to the extent necessary to avoid ambiguity or distortion of meaning.

Use one main thought per sentence. If a sentence has more than one clause and is more than 30 words long, it should be rewritten as one or more simple sentences, not to exceed 30 words.

5.3 Vocabulary

The simplest, most familiar, and most specific words which accurately convey the intended meaning shall be used. Short words and words commonly used in ordinary conversation are recommended. Use the language and idioms that the operator is trained to use wherever it makes the material easier to understand.

Use concrete and specific words to avoid vagueness (e.g., "Slowly depressurize and cool RPV" is vague. "Depressurize and cool RPV at a rate not to exceed 100^{o}F/hr using the normal makeup and letdown system" is more precise).

5.3.1 Consistent Usage

If there are synonyms for a concept, object or operation, one of them shall be selected and used consistently throughout the procedure (e.g., do not use the terms unit, assembly, equipment, and component interchangeably to refer to the same item).

5.3.2 Use of Standardized Nomenclature and Idioms

The emergency procedure shall be written using standardized terms and idioms familiar to plant operators in the nuclear industry. Equipment nomenclature shall be identical to that on the control board.

For equipment referenced in the procedure, the official term or full name shall be used for the first reference to a hardware item at the beginning of each subprocedure, followed by a shortened name, abbreviation, or acronym in parentheses. Thereafter, the shortened name, abbreviation, or acronym may be used.

A standard lexicon shall be used to simplify readability and comprehensibility of the emergency procedure.

Vague words, slang, or local jargon that might be misunderstood shall be avoided. Avoid words that are ambiguous or difficult to define. Two typical examples of such words, with their preferred alternative, are shown below.

Poor	Better
• Secure	• Stop or shut
• Monitor	• 1. Periodically check level of RWST. 2. At low-level alarm, set-point level, open pump suction from FWST. 3. Shut suction from RWST.

5.4 Grammar and Punctuation

Punctuation is used to reveal the precise relationship of thoughts. Use a word order that requires a minimum of punctuation. Use punctuation to prevent misreading. When extensive punctuation is necessary for clarity, rewrite the sentence. Rules of grammar and punctuation for standard American English shall be used.

5.5 Capitalization

Capitalization shall conform to standard English usage and shall be consistent. The following capitalization rules shall be observed:

- The first letter of the first word of each sentence or phrase is capitalized.
- All letters of the title and headings of procedures are capitalized.
- The words CAUTION, WARNING, and the words AND, OR, NOT, IF, IF NOT, and THEN are capitalized and underlined when they are used in logic statements.
- The first letter in each word of the titles of alarms, indicators, panels, and equipment names is capitalized.
- Acronyms are capitalized.
- All references to panel material, including equipment names (e.g., PORV), control designations (e.g., STBY, OFF), annunciation labels, and other panel labels, shall use capitalization consistent with that shown on the panel.

5.6 Use of Abbreviations and Acronyms

The use of abbreviations and acronyms shall be such that there is no need for licensed operators to consult a glossary of abbreviations and acronyms. Abbreviations and acronyms shall be defined on the first use in each subprocedure. When abbreviations or acronyms are used as markings on the equipment, the same abbreviations and acronyms shall be used in the procedure. Otherwise, use abbreviations in accordance with NRC's Handbook of Acronyms and Initialisms (NUREG-0544).

5.7 Use of Symbols

Symbols commonly used in the nuclear industry (e.g., °F, %, =) can be found in NRC's Handbook of Acronyms and Initialisms (NUREG-0544) and may be used in the procedure. Avoid symbols not in common industry use or everyday use. The use of symbols shall be such that there is no need for experienced operators to consult a glossary of symbols.

5.8 Use of Units

Procedures shall use units of measurement, time, or quantity that match the units written on the corresponding equipment. Any instrumentation used in the procedure must have units specified.

5.9 Use of Numerals

Use the Arabic numeral representation of a number rather than the spelled out or Roman numeral representation (e.g., 4 instead of four or IV), consistent with panel designation. The number of significant digits for a number should correspond to the precision of the display (e.g., do not use 22.23 psig in the procedure if the display is marked to the nearest whole digit--22 or 23 psig).

5.10 Tolerances

Whenever exact values are not given, allowable tolerances shall be provided rather than vaguely worded specifications (e.g., 1000 psig ±10 psig or 990 to 1010 psig rather than approximately 1000 psig). If tolerance data are not available, then comparative information may be helpful (e.g., the pressurizer level starts to drop at a faster rate).

When tolerances are given, they shall be in the same units as those on the display(s) where they are read (e.g., do not use ±3°F if the display is marked in 20°F increments).

5.11 Use of Logic Terms

The logic terms AND, OR, IF, IF NOT, and THEN are often necessary to precisely describe a set of conditions or sequence of actions. The specialized use of each of these terms is discussed below. When used in these special applications, the words should be flush with the text, capitalized, and underlined for emphasis.

5.11.1 Use of AND

Ordinarily, action steps are performed in sequence, and a conjunction such as AND is not required between action steps. When attention needs to be called to combinations of conditions or action steps that must occur jointly, then AND should be placed on a separate line between the description of each condition or action step for clarity. The word AND should not be used to join more than four conditions or actions steps. If more than four conditions need to be conjoined, a list format should be used. When used as a simple or compound conjunction, the word "and" should not be emphasized.

5.11.2 Use of OR

When calling attention to alternative combinations of conditions or action steps, then OR should be placed on a separate line between the description of each condition or action step. This use of the word OR is always in the inclusive sense, that is, A OR B means A, or B, or both A and B.

5.11.3 Use of IF, IF NOT, NOT, and THEN

When action steps are contingent upon a certain condition or combination of conditions, then the step should begin with the words IF or IF NOT, followed by a description of the condition or conditions (the antecedent), a comma (,), the word THEN, followed by the action to be taken (the consequent). The words, underlined and capitalized, shall be flush with the text.

Example:

6.22.2	IF RCS pressure is increasing, AND IF pressurizer level is increasing, THEN go to Subprocedure 6.1.	Refer to Exhibit 3, Decision Table

Whenever IF is used, the next action step or note shall begin with IF NOT, and shall tell the operator what to do if the antecedent conditions do not apply. THEN shall not be used at the end of an action step to instruct the operator

to perform the next step, because it runs actions together, which makes it difficult to verify the performance of each action step when check-off marks are used, and because it can be confused with a logic statement.

5.11.4 Combinations of Logic Terms

When AND and OR are used together, they can be logically ambiguous. For example: IF Condition A AND Condition B OR Condition C occurs, THEN go to Step 5.3.6. This statement has three alternative meanings:

1) IF both Condition A AND Condition B occur, THEN go to Step 5.3.6, or IF Condition C occurs, THEN go to Step 5.3.6.

2) IF both Condition A AND Condition B occur, THEN go to Step 5.3.6.

3) IF both Condition A AND Condition C occur, THEN go to Step 5.3.6.

In each case, the use of inclusive OR results in going to Step 5.3.6 if A, B, and C all occur. The use of both AND and OR within the same action step should be avoided. When this is not possible, the more explicit form (Example 1 or 2) shall be used.

5.12 Other Antecedents

Action steps may be contingent upon other antecedents, such as elapsed time. In such cases, the step should begin with the antecedent conditions, followed by a comma (,), and the action to be taken (e.g., When the pressurizer temperature reaches 500°F, stop the charging pump).

5.13 Use of "Will," "Can," "May," and "All"

The following rules shall apply to the use of "will," "can," "all", and "may":

- Use "will" when referring to the response of the equipment (e.g., "The RN and KC Pumps will start," or "A reactor trip will occur").
- Use "can" when referring to a possible response of the equipment (e.g., "The RN and KC Pumps can now start," or "A reactor trip can occur").

- Use "may" to refer to a human operation which is possible, but which may or may not occur.
- Avoid the use of "all." In its place, list the individual components being referred to. That is, rather than stating "Turn off all pumps," the procedure should state "Turn off Pump A; turn off Pump B; turn off Pump C; turn off Pump D."

5.14 Use of Pronouns, Articles, and Adverbs

The following rules shall be followed in the use of pronouns, articles, and adverbs.

- The emergency procedure shall be written without the use of personal pronouns, that is, use the imperative mode and active voice (e.g., Terminate RCS charging no sooner than 1.5 hours nor later than 2 hours post-LOCA.).
- Articles (e.g., the, an) may be used in textual material, but their use shall be minimized to describe action and diagnostic steps.
- Adverbs that cannot be reliably and consistently defined shall be avoided where possible. For example, "Periodically check the radiation monitors..." should be changed to "Check the radiation monitors at least every 30 minutes...."

5.15 Use of Footnotes

Footnotes shall not be used.

6.0 FORMAT OF PROCEDURES

The format or physical layout of procedures contributes significantly to their comprehensibility and can minimize confusion and operator error. Specifically, the format helps to determine how well and quickly information can be located and acted upon by the operator. The goal is to minimize the time required to read and act upon the procedure.

6.1 Cover Page

The format of the cover page is left to the discretion of the licensee/applicant, but shall include those items listed in Section 3.1.

6.2 Identifying Information

Each page of the emergency procedure shall have a shortened form of its title with procedure number, revision number and date, and page ____ of ____ in the upper right hand corner. This information should be single spaced.

6.3 Page Layout

The emergency procedure shall be typed in double-column format. The left-hand column shall be restricted to actions. The right-hand column shall be used for explanations and notes.

The binding-side margin shall be wide enough that every step can be easily read. Clutter should be avoided in page content, as well as in figures and tables. Ample space shall be provided to avoid confusion and a sense of crowding.

Each subprocedure shall start at the top of a page. Each action step shall be wholly contained on a single page, and shall not be continued on the next page. Notes and explanations shall begin next to the action step to which they refer. Notes may be continued from one page to the next. Cautions and warnings shall be on the same page as the action step to which they refer. All the lines of the text of cautions and warnings shall appear on one page (see Section 6.4).

6.4 Placement of WARNING, CAUTION, and Note Statements

In writing these statements, the following rules shall apply:

- WARNING and CAUTION statements shall always precede the task or action steps to which they apply.
- Any WARNING or CAUTION that is general enough to apply to the entire procedure shall be placed before the first action step in the procedure.
- WARNING or CAUTION statements shall be placed in a box that extends from margin to margin.
- The word WARNING or CAUTION shall be typed in all capital letters and centered inside the top of the box.
- When a WARNING or CAUTION consists of two or more paragraphs, the heading shall not be repeated above each paragraph.
- If it is necessary to precede an action step by both a WARNING and a CAUTION, they shall appear in separate boxes with the WARNING preceding the CAUTION.
- Notes shall start next to the action step to which they apply.

6.5 Check-Off Provisions

Some type of check-off shall be incorporated in the emergency procedure so that the operator can readily keep track of where he is in the procedure. A small column of space with lines (____) should be provided between the left and right columns to check off each action step. This does not apply to Immediate Operator Actions.

6.6 Divisions, Headings, and Numbering

The division or organization of the text shall be evident through the use of headings and a numbering system. The numbering should be the one used throughout this Guideline, that is, a decimal system in which the number corresponds to the level of the heading. Each action step shall be listed by its complete decimal number. When a Note is continued on the next page, the page shall start with the step number (e.g., "Step 6.5.4.1 continued").

The method of placing and standardizing headings and a corresponding numbering system is shown in the following example.

EXAMPLE

X.0 SUBSEQUENT OPERATOR ACTIONS

X.1 Verify Immediate Operator Actions

X.2 Diagnostic Steps

X.3 First Subprocedure

X.3.1 First Task

X.3.1.1 First Action Step. Followed by text on same line.

A means, such as tabs, shall be provided to assist the operator in locating the Subsequent Operator Actions section. It is recommended that another means, such as tabs of a different color, be provided to identify the beginning of each subprocedure.

6.7 Figures and Tables

Text and related figures and tables should be arranged so they can be viewed at the same time. If this is not possible, the figure shall be placed as close to its first callout as possible.

Each figure and table shall contain only that information directly relevant to a specific task or step. The intent is to provide several small, simple figures rather than a single, large, complex one containing information not relevant to the immediate task.

6.7.1 Titles of Figures and Tables

Each figure or table shall be referenced in the text by Arabic number (e.g., Figure 1, Table 2), and each shall have a title. The title shall distinguish the contents or purpose of its figure or table from others in the procedure. Each title shall identify the variables represented in its figure or table. Table titles should be centered above the table. Figure titles should be centered below the figure.

6.7.2 Figure Format

For flow diagrams, all inputs and outputs shall be clearly identified, with inputs at the left or top, and outputs on the right or bottom, respectively. The direction of flow shall be indicated by arrows; signal or pressure flow should be from left to right or top to bottom and feedback or return flow from right to left or bottom to top.

Line graphs shall depict a maximum of four relationships between the axis variables. Lines depicting relationships shall be coded for easy discrimination. Graph scales may be linear or nonlinear as required for comprehension or use. The axes shall be labeled to indicate the variables and units of measurement.

The number of grid lines used shall be such that the operator can read values to the required degree of accuracy. The grid lines shall be no less than 0.1 inch apart. Grid lines shall be easily distinguished from the graph lines, and shall not obscure detail necessary for the proper use of the graph.

6.7.3 Table Format

To avoid clutter, at least 25 percent of the area within the table shall be clear space between columns and groups of rows.

Entries shall be aligned within columns as follows:

- For decimal data, decimal points shall be aligned
- For scientific notation, multiplication signs shall be aligned
- All other numeric data shall be aligned flush right
- Alphabetic or alphanumeric data shall be aligned flush left.

Units of measurement shall be specified in row or column headings, as appropriate. Interpolation should be minimized by expanding the table or by presenting the data in a graph.

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In response to the Three Mile Island (TMI) accident, and the subsequent evaluation, the U. S. NRC has published the TMI Action Plan. This Action Plan identifies the need to provide Emergency Operating Procedures that treat the lower consequence/higher probability emergencies which had not been addressed in the past, and the need to incorporate good Human Factors practices in these procedures. The purpose of this document is to provide Human Factors input to the U. S. NRC for use in developing guidelines for writing Emergency Operating Procedures for nuclear power plants.

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